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ABSTRACT

This study examined the effects of two cognitive styles--field dependents-independents and reflectivity-impulsivity--on learning from microcomputer-based instruction. In the first of three experimental designs, a programmed instruction text on the human heart was used which contained both visual and verbal information in an instructional display, followed by an instructional question and feedback. Subjects were given visual recall tests. In the second experimental design, the same programmed instructional text was used, but verbal recall tests were substituted. The third experimental design was a pilot study designed to evaluate the performance of the subject pool from another experiment on the Barratt's reflectivity and impulsivity cognitive style test. The data from the first two experimental design groups indicated that the line drawing visual type of programmed instruction appeared to have an adequate amount of visual information for learning, and when paired with visual feedback, significantly improved learning. In addition, visual feedback was found to improve learning more than verbal feedback. It was also found that verbal testing alone did not reveal any significant performance differences in the field-dependent-independent group, leading to the observation that testing conditions for intellectual performance must be sensitive to the cognitive style factors being examined. The 180 college freshmen in the third experimental group were found to be more highly cognitively impulsive than impulsive and motor impulsive; these findings will be used in further research on learning from microcomputer-based and programmed instructional materials. The text is supplemented by six tables and four figures. (23 references) (EW)

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Cognitive Style Factors and Learning from Micro-Computer Based and Programmed Instructional Materials: A Preliminary Analysis

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Rationale

Last year's AECT Convention produced a significant number of RTD Papers on the topic of micro-computer based instruction (MCBI). In addition, other related professional areas are experiencing similar interest in the design of high quality MCBI instruction, for academic learning as well as skill development in industrial and business training. For example, a recent special issue of Engineering Education Journal (1986) was dedicated to the design of MCBI for science and engineering curriculums. The 1987 American Society for Engineering Education Annual Conference had a significant number of research papers on the design and application of MCBI for improving instruction in science and engineering (1987). A recent article by Wise (1986) indicated a similar interest in MCBI applications for business training, finding MCBI to be effective for learning and also cost effective (also, Carney 1987). Additional interest with MCBI can be found at ASTD Annual Meetings, as well as other specialized education meetings, such as The National Science Teachers Association Conference (1987). However while a significant level of interest exists for MCBI instruction, and research and development with MCBI continues, few of these presentations and studies have considered cognitive style variables. Cognitive style variables can have a significant impact upon the perception and learning of academic information (Cross, 1976). Additionally, the micro-computer seems to be the only technology allowing for a true systematic examination of cognitive style by instructional design relationships (Gagne, 1983). While early attempts at such trait-by-treatment interactions research proved less than favorable (Hunt, 1973), such learning style issues can now be examined within the context of real academic instructional situations, to observe the perceptual and learning differences caused by cognitive styles.

The present study examines two cognitive style variables, in three separate experimental designs. This study is a preliminary study, to evaluate cognitive styles, and instructional and testing conditions. A later study is planned implementing these evaluated instructional and testing materials into MCBI conditions, and further examining cognitive style effects on perception and learning.

Cognitive Styles

While much has been written about cognitive styles, there seems to be a good bit of misconception about what cognitive styles actually are, and what effect specific cognitive styles have upon learning and perception. Surprisingly, educators are now in a position to examine these individual difference types, with the use of MCBI, but few new trait-by-treatment studies have been completed.

Cognitive style was originally defined as a perceptual characteristic caused by the interaction of genetic factors and environmental factors as the individual develops or simply stated, perceptual behavior is a function of the person and environment, [B, F(P,E)], (Lewin, 1935; Cronbach, 1967; Hunt, 1973). Cognitive style can then be operationally defined as the differences in perception individuals have of information in the environment, based upon their background. In other words, the same perceptual situation may be viewed differently by two individuals, contingent upon their cognitive styles. For example, a high dogmatic individual may perceive a political candidate much differently than a low dogmatic individual views the same political candidate. Similarly, the low dogmatic cognitive style will actually "see" different things, usually more information, in the same situation as experienced by the high dogmatic cognitive style. While the cognitive style issue has implications for personality research and perception (i.e. the vast number of studies done on Dogmatism), such perceptual factors will impact upon learning (Witkin, 1873):

> "Cognitive style is a potent variable in students' academic choices and vocational preferences; in students' academic development through their school career; in how students learn and teachers teach; and in how students and teachers interact in the classroom." (p.1.)

However, while a good deal is known about the topic of cognitive styles, little of this knowledge has been used by educators, for example (Cross, 1976):

> "Unfortunately, not one teacher or counselor in a hundred knows anything at all about cognitive styles despite the fact that research on cognitive styles has been going on for some twenty-five years in psychological laboratories."

As Kogan noted sometime ago (1971), this type of situation is caused by a total lack of articulation between psychological study of cognition and those conducting and reporting educational research, and those in the practice of education and teaching. This situation should be remedied by those researchers involved in applied educational research. A variety of cognitive styles have now been identified, and most of these researched to varying degrees. Currently about 12-18 different cognitive styles have been investigated. Here is a definition of 9 of these cognitive styles developed by Messick (1970):

> 1. Field independence versus field dependence - "an analytical, in contrast to a global, way of perceiving [which] entails a tendency to experience items as discrete from their backgrounds and reflects ability to overcome the influence of an embedding context."

2. Scanning - "a dimension of individual differences in the extensiveness and intensity of attention deployment, leading to individual variations in vividness of experience and the span of awareness."

3. Breadth of categorizing - "consistent preferences for broad inclusiveness, as opposed to narrow exclusiveness, in establishing the acceptable range for specified categories."

4. Conceptualizing styles - "individual differences in the tendency to categorize perceived similarities and differences among stimuli in terms of many differentiated concepts, which is a dimension called conceptual differentiation as well as consistencies in the utilization of particular conceptualizing approaches as bases for forming concepts-such as the routine use in concept formation of thematic or functional relations among stimuli as opposed to the analysis of descriptive attributes or the inference of class membership."

5. Cognitive complexity versus simplicity - "individual differences in the tendency to construct the world, and particularly the world of social behavior, in a multidimensional and discriminating way."

6. Reflectiveness versus impulsivity - "individual consistencies in the speed with which hypotheses are selected and information processed, with impulsive subjects tending to offer the first answer that occurs to them, even though it is frequently incorrect, and reflective subjects tending to ponder various possibilities before deciding."

7. Leveling versus sharpening - "reliable individual variations in assimilation in memory. Subjects at the leveling extreme tend to blur similar memories and to merge perceived objects or events with similar but not identical events recalled from previous experience. Sharpeners, at the other extreme, are less prone to confuse similar objects and, by contrast, may even judge the present to be less similar to the past than is actually the case."

8. Constricted versus flexible control - "individual differences in susceptibility to distraction and cognitive interferences in

susceptibility to distraction and cognitive interference."

9. Tolerance for incongruous or unrealistic experiences - "a dimension of differential willingness to accept perceptions at variance with conventional experience." (pp. 188-189)

The systematic evaluation of cognitive styles, and how to design effective learning conditions for each specific cognitive style, should be further examined. However, while early trait-by-treatment interaction research studies were worthwhile, the practical application in the classroom of cognitive style specific instructional conditions proved impossible. Fortunately, today the micro-computer has changed this situation by allowing for highly individualized instructional programs to address specific learning needs.

The cognitive styles examined in the present study are field-dependents-independents and reflectivity-impulsivity. A definition of both of these cognitive styles is provided in the above listing by Messick, however a few more points on these cognitive styles. Field-dependents-independents was originally researched by Witkin (1954). His original work lead to a large number of studies on fd-fi (Witkin, Oltman, 1973), with this research yielding results having significant implications for instruction and learning (Witkin and Moore, 1975). In terms of viewing an instructional display, the field-independent student will be able to abstract relevant information more easily, probably acquire information more quickly, and require fewer individual cues. On the other hand, the field-dependent individual will have more difficulty identifying relevant to-be-learned information from the visual instructional display, and will have more difficulty learning from complex visual displays. On the other hand, the field-dependent student may learn better with more visual cues and more reinforcement. So the basics of designing an instructional display should differ significantly contingent upon relative field-dependency or field-independency. Thus, knowledge of fd or fi can predict how to design instructional events, and MCBI instructional displays.

Early work on reflectivity and impulsivity was carried out by Kagan (1965; Kagan, Rossman, et.al., 1964). Recent research on this cognitive style has been carried out by Ernest Barratt. An extensive series of studies, now done by Barratt examines the reflectivity and impulstivity cognitive style (Barratt, and Pattan, 1983; Barratt, 1980; Barratt, 1972; Barratt, 1965). Similar to fd-fi, the reflectivity-impulsivity cognitive style has implications for how students deal with the instructional environment, and specific instructional displays. For example, the impulsive learner may be less likely to view an instructional display for the correct amount of time, or may not attend to visual detail. Therefore, external pacing strategies may be needed in the MCBI program, to deal with the impulsive cognitive

style. Additionally the impulsive cognitive style may avoid feedback loops, or additional study when needed, so these considerations should be designed into the MCBI program. However, the reflective cognitive style may find such built in strategies debilitating, so a cognitive style specific instructional program may prove more effective.

Cognitive style variables are so pervasive in learners, and such powerful psychological systems, it would seem that cognitive styles should serve as a basic consideration for the design of MCBI instructional programs. Along with the optimal design of visual displays and pace considerations, cognitive style effects may help instructional developers design optimal MCBI programs for most learners.

Experimental Designs

The present research study involves three experimental designs, two investigating the cognitive style of field-dependents and field-independents and one evaluating the reflectivity and impulsivity variable.

The first fd,fi experimental design is represented by figure 1. The fd,fi variable was determined using the Thruston Embedded Figures Test. Two hundred experimental subjects were tested for fd,fi. The fd,fi scores were analyzed and split, so that the middle portion of the scores were eliminated leaving scores that were as close to being fd or fi as possible. This left 112 subjects to participate in the study. These 112 subjects were then split into fd and fi groups based upon their relative fd and fi scores.

The programmed instructional (PI) texts instructed subjects on the parts of the human heart and how the heart operated (Dwyer, 1987). Each PI text contained visual and verbal information in an instructional display, followed by an instructional question and feedback. Each PI text had exactly 37 instructional displays, and 37 instructional questions, for each display. The PI texts simulated a computer display in style, and served as a pilot set of instructional materials for later computer programming. There were two types of visuals evaluated, and two types of feedback evaluated in the PI texts. The first visual type was a simple line drawing of the heart. While this visual type was complete, with all correct information, finer detail was not in the visual. The second visual was a detailed line drawing, which included the same basic information as the simple line drawing, but with added detail. Both visual types were in black and white. An instructional display consisted of a visual of the heart, labels indicating heart parts or operations, arrows specifying parts or operations, and a brief verbal explanation under each visual.

The two types of feedback were verbal or visual. On the verbal feedback condition, after the subject responded to the

instructional question, the PI text page was turned and the correct answer was then provided in verbal form. In the visual feedback condition, after the subject responded to the instructional question, the page was turned and a heart visual appeared with the correct answer in verbal form and an arrow identifying the process or part on the visual. The two visual types and two feedback types resulted in the following four PI Instructional conditions.

1) Simple line drawing plus verbal text, and visual feedback.

2) Detailed line drawing plus verbal text, and visual feedback.

3) Simple line drawing plus verbal text, and verbal feedback.

4) Detailed line drawing plus verbal text, and verbal feedback.

After working thru the PI texts at their own pace, subjects were given a recall test. There were two types of visual tests evaluated: 1) Free recall visual test. 2) Cued recall visual test. The free recall visual test required the subject to draw a picture of the human heart, with the parts indicated and labeled, and show the correct blood flow. The cued recall visual test required the subject to draw a picture of the heart with the parts indicated, this test had a listing of the parts provided in random order at the bottom of the page. As with free recall test, on the cued test blood flow had to be shown. Both test types had 20 possible points.

The second experimental design is represented in figure 4. The second experimental design involved the same subjects, the same PI texts, but different test types. This experimental design used verbal testing in place of the visual tests from the first experimental design. There were three types of verbal tests (each had 20 points):

1) List Learning: list the heart parts and operation names.

2) Simple concept learning: given a multiple choice question describing the attributes of a part or operation, identify the correct concept.

3) Complex concept learning: given a multiple choice question which describes the interacting operation of heart functions, identify the function, relationships, or interacting parts.

The third experimental design was not a true experimental design, as were one and two. This design was a pilot study to evaluate performance of the subject pool on the Barratt's

reflectivity and impulsivity, cognitive style test. Using a subject pool from another experiment completed at Ohio State, 180 experimental subjects were given the Barratt test. The Barratt reflectivity-impulsivity test has three subscales to evaluate a subjects relative impulsivity or reflectivity

1) Non-planning
2) Motor response
3) Cognitive

The first scale deals with the ability to plan for future actions, the second deals with motor behavior of a physical nature. The cognitive scale deals with intellectual skill activities. The subject pool's reflectivity-impulsivity scores were normed for a future experiment on this cognitive style, and to determine which subscale to use for a future experiment with micro-computer based instruction. Norms on the Barratt test currently do not exist for college freshmen, our subject pool. Additionally, the scores may vary across the scales. In other words a subject may be high cognitive impulsive, and low motor impulsive. Therefore, it was necessary to determine which scale predicted relative impulsivity vs. reflectivity for this subject pool. This data on the Barratt's scales was collected as part of a separate experiment, and analyzed using a psuedo-experimental design to evaluate subscale mean differences.

The Barratt test norms will be used in a future study to evaluate the effects of reflectivity and impulsivity on learning from micro-computer based instructional programs.

Results and Discussion

The first experimental design resulting analysis of variance is summarized in Table-1. The Table-1 data yields a number of significant results. The instructional type variable was significant. A Tukey follow-up test, at .05 alpha, indicated that the PI instructional text, with a line drawing visual and visual feedback, produced a higher mean score overall on the visual tests (Table 2). The more detailed line drawing with verbal feedback produced a significantly lower score. The detailed line drawing plus visual feedback means, and line drawing plus verbal feedback scores did not differ.

The line drawing visual type appears to have an adequate amount of visual information for learning, and when paired with visual feedback, significantly improves learning. The added detail in the detailed line drawing did not significantly improve learning, however this added detail would significantly add to programming complexity for MCBI. Additionally, visual feedback is better overall, and is better than verbal feedback alone.

In general, the fi group outperformed the fd group, and cued recall was not as difficult as free recall (Table-2). These

results are expected from past research on fd, fi and cued, free recall.

A significant interaction occurred between instruction and testing type, the means involved in this interaction appear in Table-2, with a graph of the interaction in Figure-2. The source of the interaction is the PI-text type of line drawing plus visual feedback. This instructional condition produced a highly significant improvement in learning performance on the cued recall visual test. As in the main effect mean differences, this line drawing instructional display condition, with visual feedback, was better for learning visual information than a detailed line drawing and verbal feedback. However, free recall of visual information remains a difficult task as indicated by the mean scores in Table-2.

A significant interaction occurred between fd, fi and test type (Table-2, Figure-3). The field-independent group did significantly better on the cued recall test than did the field-dependent group, but both cognitive styles had more difficulty with the free recall visual test.

Interestingly, a highly significant finding, is the lack of significance found in the second experimental design (Figure-4). The Table-3 analysis of variance results indicated that verbal testing alone failed to reveal performance differences, in performance with the cognitive style of field-dependents-independents. In other words, if the experimenters used only verbal tests, and not visual testing, our results would have been quite different, or insignificant. This lack of significance with verbal testing, using the same instruction and same subjects, points out a key issue with cognitive style research; testing conditions for intellectual performance must be sensitive to the cognitive style factors being examined. The cognitive style will always be at work, since it is an innate psychological factor, but if criterion tests are insensitive to the cognitive style examined, results will fail to reveal performance differences. A comparison of the Table-1 and Table-3 results makes this principle obvious, and yields the conclusion that visual testing should be a consideration for examining the field-dependent and field-independent cognitive style. In addition, it makes obvious the need for pilot testing instructional and testing materials for cognitive style sensitivity, when researching cognitive styles and instructional factors.

Well, what did we learn from this preliminary analysis for our next study on MCBI? First, our MCBI instructional programs will eliminate the detailed drawing, plus verbal feedback condition. This instructional condition will be replaced with a condition to examine visual cuing during instruction, and if this extra visual cuing will improve free recall test scores, and overall visual test scores for field-dependents. Secondly in our next MCBI study, with the original three PI-Instructional

conditions adapted to MCBI, we plan to eliminate verbal testing. However, along with the free recall and cued recall visual tests, we will add a visual oriented test to evaluate concept understanding. In other words, this third test will evaluate conceptual ability with the heart content, but include a visual dimension during testing. Thirdly, in the follow-up study, from this pilot study, we will further evaluate fd and fi, but with the added effects of an MCBI method of instruction, a visual cue oriented instructional condition, and a visual concept test.

The psuedo-experimental design is summarized in Table-5, relevant reflectivity-impulsivity mean scores are presented in Table-6. While this analysis includes data from another study, the only relevant variable is the cognitive style mean scores, and in Table-5 the data listed as 3-Subscales. This relectivity and impulsivity data was collected as part of another study evaluating 8 instructional conditions. The analysis of variance design in Table-5 was only used to norm the 3 reflectivity-impulsivity subscales for future work.

The three subscale means proved to be statistically different for this group of 180 college freshmen. They tended to be more highly cognitively impulsive (18.71), than planning impulsive (14.92), and motor impulsive (16.93). Additionally, their overall mean scores on the three subscales tended to fluctuate a great deal from subject to subject. Therefore, it may be difficult to use all three subscales in one experimental design, but better to examine one subscale at a time. Since the cognitive subscale seems to relate more closely to academic work, our next cognitive style experiment dealing with reflectivity-impulsivity, will evaluate relative performance using the cognitive subscale.

Finally, these norms on the three subscales are valid for college freshmen, since our subject sample size was 180 in this case. However, since little is known about reflectivity-impulsivity for college students, more should be done on developing norms on the Barratt test on this cognitive style.

	LD, Vis.F. Line Drawing, Visual Feed.		DD, Vis.F. Detailed Drawing, Visual Feed.		LD, Ver.F. Line Drawing, Verbal Feed.		DD, Ver.F. Detailed Drawing, Verbal Feed.	
	fi	fd	fi	fd	fi	fd	fi	fd
Cued								
Free								

Figure 1: Visual testing, fdfi, Experimental Design

Source	Mean Sq.	Df	F-Ratio	P
Instruction (I)	34.68	3	2.77	.05
(fi) x (fd)	52.94	1	4.23	.04
(I) x (fd,fi)	17.72	3	1.42	.24
Test (T)	167.58	1	13.39	.001
(I) x (T)	35.79	3	2.86	.04
(T) x (fd,fi)	87.51	1	6.99	.01
(T) x (I) x (fd,fi)	5.29	3	.42	.74
Error	12.51	96	----	---

Table 1: ANOVR Summary Table Visual Testing

Instruction Means:

LD, Vis.F.	DD, Vis.F.	LD, Ver.F.	DD, Ver.F.
7.82	6.68	6.50	5.11

fi x fd Means:

fi	fd
7.21	5.82

Test Means:

free	cued
5.30	7.75

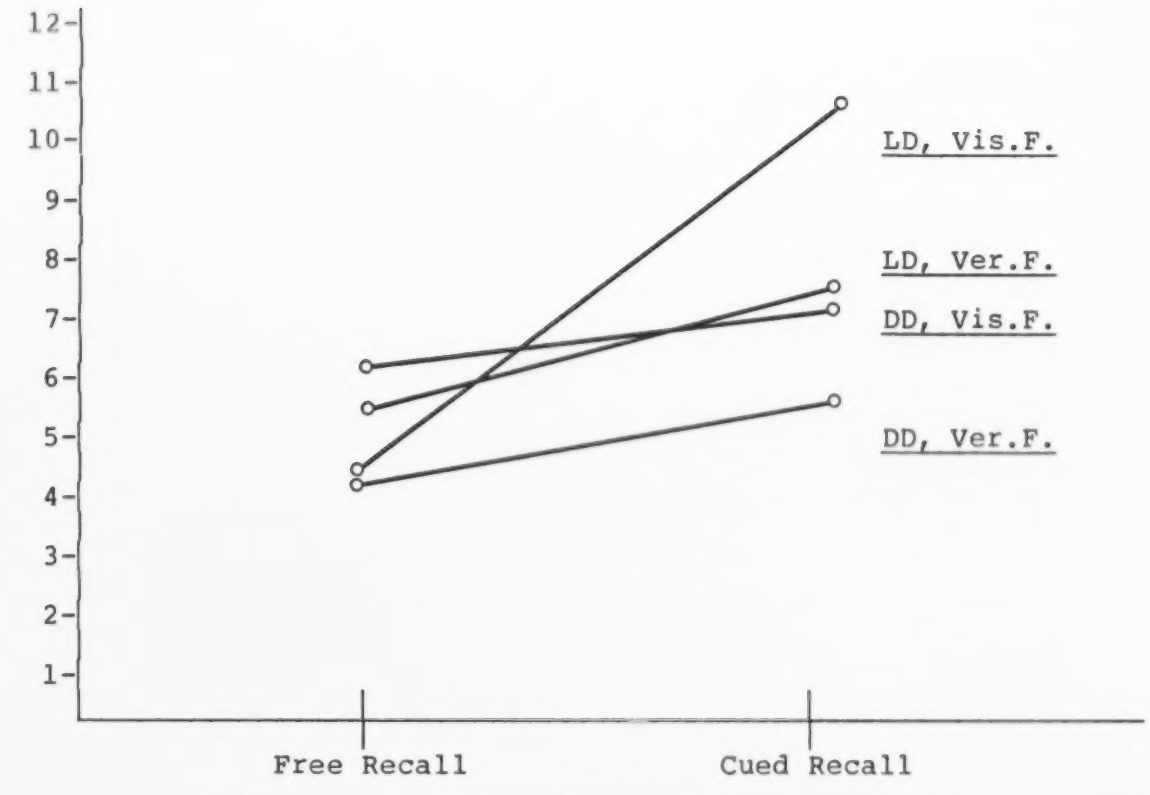
Instruction x Test Interaction Means:

(LD, Vis.F.)		(DD, Vis.F.)		(LD,Ver.F.)		(DD, Ver.F.)	
Free	Cued	Free	Cued	Free	Cued	Free	Cued
4.73	10.71	6.29	7.07	5.64	7.36	4.36	5.86

Test x fd,fi Means

(Free Recall) fi,	(Cued Recall) fi,
5.11	9.32
(Free Recall) fd,	(Cued Recall) fd,
5.5	6.18

Table 2:_ Significant Resulting Means,_Visual Testing Experiment_



(figure 2: Instruction x Test Interaction)

(figure 3: Test x fd,fi Interaction)

	LD, Vis.F. Line Drawing, Visual Feed.		DD, Vis.F. Detailed Drawing, Visual Feed.		LD, Ver.F. Line Drawing, Verbal Feed.		DD, Ver.F. Detailed Drawing, Verbal Feed.	
	fi	fd	fi	fd	fi	fd	fi	fd
List Learn								
Simple Concept								
Complex Concept								

Figure 4: Verbal testing, fdfi, Experimental Design

Source	Mean Sq.	Df	F-Ratio	P
Instruction (I)	34.89	3	.964	.41
fd,fi	128.76	1	3.56	.06
(I) x (fd,fi)	40.69	3	1.13	.34
Error	36.18	104	----	---
Tests (T)	171.74	2	28.88	.001
(I) x (T)	7.85	6	1.32	.25
(fd,fi) x (T)	5.32	2	.90	.35
(fd,fi) x (I) x (T)	6.03	6	.42	.39
Error	5.94	208	----	---

Table 3: ANOVR Summary Table Verbal Testing

List = 11.01; Simple Concept = 10.26; Complex = 9.13

Table 4: Significant Testing Means

Source	Mean Sq.	Df	F-Ratio	P
By Group	53.59	7	1.35	.23
Error	39.76	152	----	---
3-Sub Scales	576.34	2	32.99	.001
Interaction	16.87	14	.97	.49
Error	17.47	304	----	----

Table 5: ANOVR: Reflectivity Impulsivity Norms; Psuedo Experimental Design Results

3-Sub Scale Means		
Non-Planning	Motor	Cognitive
14.92	16.93	18.71

Table 6: Significant Reflectivity x Impulsivity Means

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